Quarterly EOS Contract Report - Report #51

Period: January 1 - March 31, 1996

Remote Sensing Group (RSG), Optical Sciences Center at the
University of Arizona

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Report compiled by: K. Thome

Summary:
Work by members of the RSG during the past quarter consisted of Science Team support activities including the attendance at meetings related to MODIS, writing of the Validation Plan for ASTER and MODIS calibration, and work on the atmospheric correction of ASTER data and the solar-radiation-based calibration (SRBC) of MODIS. First measurements were made with the SWIR CCR. We continued improvements to our calibration facilities and blacklab including upgrades to software to simplify data collection. We received a new Cimel TIR field radiometer and began characterizing it. Machining of the cosine collector for the diffuse-to-global meter was started. A comparison of three radiometer calibration techniques was nearly completed and work began on processing AVIRIS data for last July's Lake Tahoe campaign. Field work activities were continued with trip planning for a May-June vicarious calibration validation campaign to Nevada.

Dr Edward F. Zalewski plans to join the RSG as a Research Professor in June 1996. Briefly, his past experience includes 20 years at NIST where he earned an international reputation for his pioneering work on the development of detector-based calibration, he joined Hughes Danbury Optical Systems in 1990 where he has been in charge of designing and testing the calibration systems for NRL's HYDICE and DOE's Multispectral Thermal Imager. With Slater's reduction to about half time in June, Zalewski will assume the responsibility for the supervision of the RSG.

Task Progress:
P. Slater was awarded the William T. Pecora Award in Las Vegas on February 27 for his contribution to remote sensing in the area of radiometric calibration. S. Biggar, S. Recker, P. Spyak, and K. Thome attended the award presentation.

Slater forwarded a set of view graphs to J. Butler describing plans for a Joint Vicarious Field Campaign from May 30 to June 7. Butler used these for a presentation at the Test Site meeting in March. Slater attended an MCST review at GSFC in January where he presented a progress report on RSG activities since the last review. He supplied W. Esaias, the chair, several comments on the MCST presentations which were incorporated into the final report. Slater met with G. Asrar on January 24 and discussed the progress of three RSG students who have Earth System Science Fellowships. He discussed SeaWiFS related matters with R. Frouin and sent him material needed for the Moscow meeting Frouin attended one-week later.

"Validation Plan for the on-board calibrators and the vicarious calibration of ASTER and MODIS", authored by Slater, Biggar, Spyak, Thome, P. Abel, H. Kieffer, and F. Palluconi was submitted to the ASTER and MODIS offices at JPL and GSFC on March 7. Biggar, Slater and Thome met with A. Kahle and Palluconi of JPL and K. Arai and S. Machida of the Japanese ASTER Science Team on March 11 at the RSG to discuss the ASTER Calibration and Validation Plans.

On March 18 and 19 Slater attended the Land Test Site meeting at GSFC and chaired two splinter sessions on Vicarious Calibration. These resulted in a report written by Butler. On the second day, Slater was also involved in a discussion of how the ASTER and MODIS Validation Plans should be presented. The meeting included Butler, B. Guenther, Kahle, M. King, R. Murphy, S. Reber, P. Sellers, and D. Starr. It was decided the ASTER and MODIS Plans should be submitted separately. A decision was not reached on the division between the MCST Validation Plan and the one referred to above. Murphy is to lead a discussion on this matter on April 30 at the Calibration Working Group meeting preceding the MODIS Science Team meeting. On March 20 Slater attended an MCST meeting at which Murphy, M. Roberto and R. Weber were also present. Validation Plan strategy, reflectance- and radiance-based calibration were discussed. On March 16 and 17 Slater attended the SWAMP meeting at Valley Forge.

Slater and Biggar discussed by telecon the SRBC of MODIS with T. Pagano of SBRS. Subsequently an email was sent to several people at SBRS and GSFC regarding the suggested approach agreed by telecon. Basically, it involves writing a Test Agreement, to outline the approaches, implementation, error budgets and costs of the UA method and the GSFC method. This will be sent to D. Weber for his approval. Biggar and J. Young of SBRS determined the heliostat mirror may not be flat enough for the experiment. Subsequently, the Quarterly Management Review at SBRS the week of March 25, it was concluded that both the radiance and reflectance SRBC experiments should be performed for MODIS. The immediate plan is for Biggar to accompany Waluschka to optically test the heliostat mirror. The flatness of this mirror is considered to be the most critical concern for both calibrations.

Biggar and Slater attended a HYDICE meeting and presented results of in-flight stability checks and cross-comparisons between HDOS, UA, MTL, and JPL calibrations. These topics will be presented at the SPIE Denver '96 meeting by Slater and Biggar. Biggar also submitted two abstracts to the Denver meeting on HYDICE out-of-band problems and HYDICE laboratory radiometric calibration.

P. Spyak reviewed "Radiometric Calibration Effects of NFR (size of source): CPR action item #20" memo by J. Young of SBRS and provided comments to E. Knight. K. Thome emailed comments on LUT size and atmospheric correction CPU requirements to M. Pniel of JPL. He sent input to C. Leff for the ASTER software description document and sent A. Schwartz comments on the ASTER Software Data Requirements document. R. Parada attended the IVOS meeting in Toulouse on Feb. 19-20 and gave a brief talk on current terrestrial work being done by RSG.

Biggar and E. Nelson successfully tested the new VNIR CCR but are debugging controller/computer problems. Biggar used the prototype to measure our FEL lamps for comparisons of Langley and lamp-based calibrations of B. Schmid's solar radiometer. Biggar also used the radiometer to measure the radiance from a barium sulfate panel with the same FEL lamp and radiometer and began data reduction. Nelson modified the shipping rack of the CCR to accommodate the lock-in amplifier for the SWIR CCR and mounted the Hydra and SC5000 SIS controller. He is completing thermal and baffle modifications for the second version of the VNIR CCR. Biggar and J. LaMarr made SRBC measurements using the prototype, and Biggar, Nelson, and C. Burkhart developed a new sight for the radiometer. Biggar modified the new radiometer to reduce warm up time.

Spyak received the bandpass filters from Barr and the detector from Cincinnati Electronics for the SWIR CCR. He reviewed the data sent by Cincinnati Electronics (FOV, noise, quantum efficiency, detector uniformity, and frequency response) and quick testing showed the responsivity and noise are reasonable. The entire radiometer was assembled to check the mechanical design and a few improvements and corrections were made. Spyak and LaMarr learned to use the lock-in amplifier and began programming the computer interface to the amplifier. Spyak obtained shipping cases for the radiometer and tripod. He determined how to mount the system to the tripod and the methods for tip-tilt and rotation. A rotation stage was purchased and Burkhart fabricated a tip-tilt stage. Nelson assembled the power supply for the detector amplifier and made a power supply cable. Spyak performed dewar response, dark signal, and noise measurements for various setups of the radiometer and lock-in configurations. He performed initial dewar stability and repeatability tests. Spyak made FOV measurements of the detector and determined it to be 3.92 degrees at FWHM. Spyak evacuated the dewar. A full test of the system was made using the 40" SIS. The signal levels from this experiment are reasonable and the SNR was greater than 10,000 for all bands. The instability of the measurements was limited by the sphere's instability and measurement repeatability was better than 0.11%.

At the start of the quarter our Optronic monochromator was still broken. The chopper moved when it should not, did not position itself correctly, and did not chop at the set frequency. The system was repaired by the manufacturer. The source power supply then failed and Nelson fixed the problem. LaMarr and Spyak checked its alignment and performed spectral calibrations. LaMarr calibrated the first grating and the shorter wavelengths of the second. The longer wavelengths of the second and the entire third grating were not calibrated because we do not have strong line sources at those wavelengths. Spyak evacuated the InSb dewar for the system. J. Myers used the Optronic to measure the out of band rejection for several unknown interference filters. The electronic temperature control circuit of the Mikron blackbody failed and was repaired and calibrated by Mikron.

M. Sicard returned to the group in December and his work for the next 16 months will focus on a detailed characterization and calibration of a recently received CIMEL TIR radiometer, including both field and laboratory work. Sicard and Spyak decided the primary characterization effort will be dark noise tests, field-of-view measurements, linearity tests, absolute calibration, and spectral-bandpass calibration. The two measured the field of view of the radiometer which Sicard found to be about 9.4 degrees (10 degrees is the theoretical value). Sicard also detected small humps on both sides of the curve which he thought was due to the instrument housing, but painting the housing did not improve the out-of-field response. Further FOV measurements were made with the nernst glower without the collimator and this produced a broader angular-response curve, had lower in-field signal and larger out-of-field. Sicard compared measurements of different sources using the Everest and the CIMEL radiometers and, of course, found different results. He will repeat this experiment including the new Rs-5900 ECPR. Sicard also performed linearity tests using 8 apertures machined by Burkhart. Band 1 (8-13 micrometers) of the radiometer gave a correlation coefficient of 0.9992 to a linear fit and the results are better for the other three bands. Sicard used a varying blackbody source for a second linearity test and found a correlation coefficient of 0.99994 in the range of 263 to 353 K. Measurements were also made to get an absolute calibration of the system. These results allow measurements of temperature to better than 3% for temperatures greater than 298 K but with uncertainties as large as 9% for temperatures less than this. Sicard also began preparing for a field experiment with scientists from USDA/ARS, and INRA the beginning of May near White Sands where he will use the Cimel radiometer and compare its measurements to several other radiometers. In other related TIR work, Myers began to familiarize himself with the Everest and MMR radiometers and became familiar with the operation of the blackbody simulator.

P. Spyak had the blacklab multimeter, power supply and shunt calibrated and renewed our repair, maintenance, and calibration agreements for the multimeter and power supply. LaMarr, Myers and Spyak began work on blacklab improvements. Myers began investigating possible shutter-chopper assemblies and familiarized himself with the chopper and shutter operations, as well as the lock-in amplifier. Biggar developed software to control the blacklab lamp current to better than a milliamp for over two hours. Biggar got new versions of the software for the Sun GPIB controller and installed and tested it. He installed and tested a new version of LabView and modified our blacklab software to run on our Sun network. LaMarr continued to set up Windows NT on the blacklab computer and successfully controlled a GPIB instrument through LabView. Spyak and

Burkhart made blacklab modifications to mount a field reflectance standard from ASTER Team Member, K. Arai which Biggar and Spyak calibrated. LaMarr installed Service Pack 4 for Windows NT on the blacklab computer, wrote directions for alignment of rotation stages in the blacklab, and calibrated our #2 barium sulfate, field-reflectance standard for the Lunar Lake trip.

B. Crowther completed the renewal of his NASA fellowship for the design and construction of the diffuse-to-global meter. He completed the mechanical design and drawings of the sphere, sphere housing, and fiber holder for the instrument, and purchased a tripod. Crowther began finalizing details of the designs for the support yoke for the elevation rotation and the column support for the sphere and began revising the leveling base. He investigated the mechanical properties of several aluminum alloys for use in various parts of the diffuse-to-global meter. The 6061 alloy series will be used for most of the structural components, except in high stress areas, where the 2024 alloy series will be used. Both require coatings in corrosive environments, and both possess similar strength characteristics, but Burkhart prefers the 2024 series. Crowther purchased the metal products required by the mechanical design and also purchased the machining tools. Crowther selected Delrin to provide low friction drag on the manual azimuth adjustment because it is harder and holds shape better than Teflon. Crowther designed the mounting system for the sighting telescope used to align the instrument in the field. He selected a quadrant-cell detector from UDT because of the dimensions of the detector and its availability. The detector is to be delivered sometime in April. Two different bearings were obtained for the instrument. One helps support the quadrant-cell detector and the other supports one side of the occultor as it is rotated to different elevation positions. The modifications and components added to the instrument required the centers of mass and mass moments of inertia of both the elevation and azimuth rotations to be computed. This must be done before the drive motors can be properly specified. Burkhart began machining two cosine receptors for the diffuse-to-global meter. Each receptor is in two parts, so Burkhart also looked at Spectralon's ability to hold threads for screws. Burkhart is confident the cosine receptors can be machined according to Crowther's designs, although the fragile nature of the Spectralon material requires great care.

R. Parada began his six-month stay in France and work with R. Santer in January. He started a report detailing three methods of MMR calibration and reduced MMR measurements from the October, Rayleigh-based calibration data sets. He carried out an error/uncertainty analysis of the Rayleigh-based calibration method, refined the error bars used for the code inputs, and began computing gaseous transmittances for this work. He re-formulated a spreadsheet used to compute the lamp-based MMR calibrations using the new lamp irradiance measurements of Schmid and Biggar. Parada organized the multiple versions of the Successive Orders RTC for use in upcoming sensitivity and calibration work. He assembled a listing of nominal conditions for Lake Tahoe and the "open, clear ocean" and developed a list of required permutations for a sensitivity analysis of Successive Orders. These permutations will be finished in the month to come. He modified the code to include an updated wave-slope model and began trials to compare the results to the old model. While doing this he determined that Successive Orders does not work for low windspeeds (below about 2 m/sec) because the probability density function is too sharply peaked for the algorithm to adequately partition and integrate. As suspected, substantial discrepancies (as great as 100%) occur in the region of sunglint. In addition, sizeable errors (over 2%) occur for the VNIR far from sunglint. Parada developed a low-windspeed "patch" but this was not successful. Thus different options must be selected depending on the windspeed. A synopsis of the findings will be sent to the code creator/manager J. Deuze. Parada and Santer discussed ways to utilize Successive Orders with aircraft measurements to retrieve TOA radiance measurements. JPL supplied Parada with an AVIRIS image of Lake Tahoe collected during last summer's Lake Tahoe experiment.

Scott continued development of the Cross-Calibration Software being written in IDL. Currently, most of the development centers around the creation of user interfaces using IDL widgets (graphical user interfaces). Specifically, a general module architecture is being developed comprised of functions and capabilities to be shared by all modules. Such items as the implementation of the Event_Handlers, the program exit function, the method in which variables will be passed between modules, are all being developed to ensure commonality between modules. Scott received a new IDL Widget Development manual from Research Systems that has assisted greatly in this part of the program development effort.

C. Gustafson submitted her IGARSS'96 paper on Landsat-SPOT cross-calibration. The ASD FieldSpec was returned from the manufacturer with a longer fiber optic and upgraded SWIR spectrometers. Gustafson collected data of the VNIR CCR's six-inch SIS to evaluate the spectroradiometer. The upgrade of the system appears to have reduced the noise in both SWIR spectrometers. The upgrades require the system to be warmed up for at least 30 minutes to ensure the system is thermally stable. In addition, the VNIR data at wavelengths longer than 850 nm is affected by heat from the SWIR TE coolers. Gustafson downloaded the alpha version of a new ASD FR executable program and will test it for ASD. She developed cross-calibration software which processes all three SPOT-TM band pairs and began to use the October 1994 data set to simulate larger footprint sensors.

M. Chami, a visiting French student who joined the group during January, looked at the Lake Tahoe data collected last June. He processed the atmospheric measurements to obtain the needed input parameters for the Successive Orders radiative transfer code and modified a new version of this code to include the radiative transfer in water. Simulations with the successive orders were performed with the optical parameters derived from the ground measurements to perform an atmospheric correction of the aircraft data. He wrote software to read the AVIRIS images and atmospherically corrected both the MMR and AVIRIS data. The lake-level reflectance of the MMR is consistent with AVIRIS and seems to validate our model atmosphere. Directional effects of the surface are observed in regions of high scattering on the lake. Chami also started to use the hydrolight code for in-water radiance calculations to study these high-scatter areas.

Thome completed the SPOT calibration reports from the October campaign and these were sent to CNES. He continued work on the ASTER LUT generation and tested the doubling/adding RTC from T. Takashima of ASTER to prepare comparisons with Gauss-Seidel results. Thome also began evaluating errors in predicting TOA radiances from interpolation of LUT results. This work will be used to attempt to reduce the size of the ASTER LUT. Thome began familiarizing himself with the operation of the BRF camera's image processing software and made preliminary plans for a joint RSG-Japanese field campaign in March. Thome sent comments to M. Pniel and G. Geller regarding the size of the LUT for the VNIR/SWIR atmospheric correction for ASTER.

Members of the group performed numerous action items in preparation for a field campaign to Nevada in March. Crowther painted labels on our Exotech boxes. Spyak received information from Labsphere on large Spectralon panels for field use. Gustafson obtained a new case for the MMR. Myers learned to set up the met station and became familiar with the test sites used by the group. LaMarr ordered cases for our Tracor Radiometric Calibration Targets and made filter transmittance measurements of the autotracker filters. LaMarr began reading the manuals for the A/D converter and the digital IO boards of the autotracker. R. Kingston began working with our Polycorder XL data logger. From March 12-16, Biggar, Myers, Slater and Thome visited Ivanpah Playa, Lunar Lake and Railroad Playa to familiarize the Japanese with the sites and collect sample data. This was in anticipation of a joint ASTER, MISR, MODIS field campaign in the period May 28 to June 7, 1996 to compare top-of-atmosphere-radiance vicarious calibration results.

R. Kingston loaded Solaris 2.5 on triton and installed Sun's commercial (unbundled) PPP on spectra. Biggar started work on getting Solaris on Intel to use for field data reduction. He ordered compilers and installed x86 on a new HD. He and Recker learned how to change WP documents into pdf files. Biggar installed Adobe and learned how to use Adobe to create a

Postscript output file from the document. This file is converted by Adobe Distiller to create the .pdf file. If set up correctly on the machine, the Netscape (or OS/2 Web Explorer) browser can launch the Adobe reader to view it. The MODIS administration team wants documents delivered in PDF format. Biggar ordered a new DDS-2 DAT drive for backup purposes.

Future work:
Biggar will finish his FEL comparison work and continue evaluating the new CCR radiometer. When the Optronic monochromator is available, he will measure the CCR radiometer filters. He also intends to travel to Flagstaff to measure H. Kieffer's source and see how to correct HYDICE data for heartbeat. Biggar will travel to Barstow, California to examine the heliostat mirror for the MODIS SRBC. Biggar and Slater will attend the MODIS Science Team meeting April 29-May 3. Thome will attend the ASTER QA/Test Workshop in Seattle from April 29-30. Slater and Thome will attend the Validation Workshop, IWG, and SWAMP Land Workshop at GSFC in May.

Spyak will continue characterizing the SWIR CCR by looking at the system's FOV, stability, repeatability, and filter transmittance.

Crowther will finalize cone support and occulting arm designs based on tests by Burkhart. If the results are as expected, it should only take a couple of days to complete these designs. Crowther will present on a talk to the Council for Optical Radiation Measurements on computer modeling of integrating spheres. The meeting is in Gaithersburg, Maryland, on May 21- 23.

Parada will complete MMR calibration work and begin inter-comparisons of the 3 methods. Results are expected to compare poorly since MMR bands are 'wide' and the spectral transmittances of the band filters were not measured. He will select wavelengths from the AVIRIS data which coincide with the MMR bands. These data will be used to conduct a radiance-based calibration of AVIRIS over Tahoe and compare the results to the Ivanpah reflectance-based results. Parada will finish sensitivity study permutations for Successive Orders and work on evaluation of methods for transferring radiances to TOA.